

Commentary

# Sick-Building Syndrome

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The sick-building syndrome (SBS) is defined as the occurrence of an excessive number of subjective complaints by the occupants of a building. These complaints include headache, irritation of the eyes, nose, and throat, lethargy, inability to concentrate, objectionable odors, and less frequently, nausea, dizziness, chest tightness, etc. These complaints will always be reported by a fraction of the occupants of any building if a questionnaire is administered that asks the respondent to recall any subjective symptoms they remember having had in the last 2 weeks or over some period of time. It is often considered that SBS symptom reports have a minimum prevalence of about 15 to 20% for a 2-week recall period. SBS symptoms reported by 30% or more of occupants are indicative of conditions in the building environment that warrant attention. It is not often that a clear, single cause is responsible for the excess symptom reports. The following factors, often in combinations, are seen to contribute to SBS: outdoor air supply that is inadequate, ventilation distribution or effectiveness that is inadequate, the presence of temporary or long-term sources of contaminants such as tobacco smoke, adhesives, composite materials such as chipboard, and the growth of microorganisms in the HVAC equipment or in carpets or other furnishings. Depending on which causes contribute, the condition may be intermittent or even temporary. Psychosocial factors such as labor-management relations and satisfaction or dissatisfaction with other factors in the work environment can have a profound influence on the level of response of the occupants to their environment. Although hard data are difficult to collect, it is likely that productivity in the office environment is sensitive to conditions causing SBS.

## Introduction

The term "sick-building syndrome" (SBS) or "tight-building syndrome" has been used to describe the situation in which building occupants express their dissatisfaction with the quality of the overall indoor environment in a building. In the classic case, neither the causal factors nor the adverse outcomes can be specifically identified, and the main identifying observation is a syndrome in which the normal background incidence of complaints of headache, eye, nose, and throat irritation, fatigue, and dizziness and nausea is elevated.

When such situations develop and are investigated, one is struck by the lack of specificity of the possible causes and a similar lack of specificity in the outcomes reported. The symptoms making up the syndrome are common and can be elicited from among the occupants of any building. The fraction of occupants admitting to such symptoms is unfortunately in part a function of the precise instrument used and how and when it is administered. In most normal buildings, between 10 and 20% of the occupants will admit to having had one or more of the SBS symptoms in the preceding week. In a building with a compromised environmental quality, the fraction of occupants admitting to symptoms of SBS is elevated, but it is difficult to identify a critical level above which this compromised environmental quality should be addressed. It is rare to find a fraction of occupants with SBS that is as high as 50%.

It is important to realize that whenever the fraction of occupants with complaints increases, there is also an increase in the much smaller fraction of occupants producing signs of building-

related illness (BRI). There is thus likely to be a range of reactions, from a small increase in minor complaints which can be elicited, to serious impact on a few individuals with preexisting conditions, which are aggravated by contaminations present in the building atmosphere. Increases in the level of contamination can then be seen to produce a corresponding shift in the number of occupants who are affected.

## Nature of Contaminants

The study of the air in a building thought to have produced an increased incidence of SBS tends to be both productive and frustrating at the same time. The number of contaminants is often very high, and they are usually present at very low concentrations. The contamination can have a biological origin and consist of bacteria and fungi, the toxins produced by microorganisms, pollen or housedust mites, or proteins shed by people, pets, or pests. Another class of contaminants is associated with tobacco smoking. Volatile organic compounds are associated with a range of building materials, finishes, cleaning agents, cosmetics, and consumer products. Characterization of the contaminants is a necessary step in finding out which sources are involved and how much they are likely to emit in a variety of settings, and what concentrations are likely to be produced. Knowledge of the indoor emissions from different products is necessary before we can work effectively toward a reduction of emissions and concentrations in the building environment. However, in dealing with a particular building, it is very unusual that knowledge of the variety of contaminants and their concentration is helpful in identifying the source of contaminants, assessing the efficacy of the ventilation system, or in explaining the increased incidence of SBS complaints. The nature of the

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corrective action required is also not often dictated by the precise nature and quantity of contaminants.

The sick-building phenomenon is clearly an example of a public health issue in which a complex of causes creates a condition that also has a complex of outcomes. Smoking cigarettes and the passive exposure to others' tobacco smoke similarly is characterized by a large number of contaminants occurring simultaneously but not necessarily in the same proportions and the likelihood that in different people different adverse outcomes from irritation to aggravation of preexisting disease will occur.

## Contributing Causes to SBS

We have to recognize that in dealing with occurrences of SBS, and even in the prevention of such occurrences, we will most benefit from an understanding of the genesis of the condition. Precise knowledge of all the parameters of exposure and outcome is less useful. There is a record accumulating of investigations of SBS-type problems. That record appears to indicate that the development of the problem is often associated with factors in the design and use of the building and its systems, rather than the introduction of particular contaminants. This suggests that remediation and prevention will often take the form of changing the patterns of use and the patterns of maintenance of a structure and its systems.

Any one of the factors in Table 1 describes a contributor to risk of developing SBS in a given building. Combinations of the factors in the table are correspondingly more powerful. Buildings designed for residential use that have been converted into office use without major modification in the HVAC system will have inadequate ventilation. If an office building is remodeled for increased occupancy density, this will also require increased ventilation. Low ventilation efficiency occurs when a part of the ventilation air supplied to a space is returned without having reached that part of the space where the occupants are. When air is supplied through diffusers in the ceiling and the return is also in the ceiling, then there is a high likelihood of reduced ventilation efficiency. If strong sources of contaminants are used in renovation, the ventilation system will be unable to remove the contaminant adequately from the space in which renovation is going on, and, in addition, the recirculated air will carry the contamination to other spaces that are not directly affected. It is rare to find a clear structure for accountability between all these participants, i.e., engineers, the building contractors, the owner, the property management, the tenants and the occupants, or a record of decisions and implementation of decisions affecting indoor air quality.

It can be seen from Table 2 that the responsibility for a good indoor air quality is the joint responsibility of a number of entities. Without setting up facilitated pathways for communication and mechanisms for periodic inspections and maintenance and for the recording of such activities, it is easy for divided responsibility to break down.

**Table 1. Causes contributing to sick-building syndrome.**

Building occupancy above design occupancy
Low ventilation efficiency
Renovation using strong contaminant sources
Inadequate maintenance of HVAC systems
Inadequate training of operators of complex building systems
Condensation or leakage of water
Low employee morale, lack of recognition

**Table 2. Participants in the determination of indoor air quality in buildings.**

Developer/designer/engineer/contractor
Complex building systems, ease of maintenance
Appropriate location of air intakes, exhausts
Ventilation efficiency
Owner/operator
Adequate system maintenance, adequate air intake
Alteration/renovation with proper review
Choice of appropriate materials for cleaning, disinfecting, pest control
Tenant/occupants
Controlling occupant density
Introduction of new pollutant sources
Positive labor-management relations

It is important to recognize in each setting that the reactions of the occupants are probably the most sensitive monitoring of indoor air quality that can be accomplished. Occupants should be given an individual to whom inquiries and complaints can be addressed, so that their observations can effectively act as early detection. Operating personnel should be given a written schedule of inspections and maintenance operations that should be followed. Evidence of such activities should be recorded in a log kept for this purpose, and that log should be accessible to the occupants' contact person as well as to the tenants and owners. The log should also have a record of occupant complaints, giving the dates and the number of inquiries or complaints received in different parts of the building. Regular review of the log created in this fashion will have the effect of identifying the source of problems encountered, and the temporal relationship between complaints, and manipulations or interventions in the operating system.

Litigation around SBS and BRI has resulted in the commitment of often substantial resources to investigations of the instances involved. Such investigations have not produced clearer insights in the relationship between specific contaminants and the adverse outcomes in specific individuals. More often, the insights resulting from these investigations relate to general principles of the design of buildings and associated mechanical systems, general principles of operation and maintenance, and of the form of occupancy. The weight contributed by these sets of principles may vary in specific cases, but in almost all cases all these factors play a role.

## Conclusions

If the past experience is to guide us, then the detection, diagnosis, remediation, and prevention of SBS and BRI is best accomplished by focusing on the communication between all the parties involved in the production, operation, and maintenance of a healthful environment in a building. Such communication should involve mutual accountability and keeping appropriate and accessible records of design, installation, maintenance, and inspections, as well as occupancy.

The air in a building is provided to each occupant by mechanical systems that usually do not allow the occupant to affect the quality of his or her personal environment as is possible in a residence. The complexity of ventilation systems including the choice of air intake location is such that proper control and operation cannot be automatically assumed, but must be assured in a positive way by a cooperative effort and accountability of all the parties involved. In a large building, the quality of the air deserves and needs the same type of assurance of healthfulness that we already expect from the systems that produce our drinking water and food.